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## SOME PROBLEMS IN REGARD TO ALIMENTARY SENSITIVITY

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By IVY G. CAMPBELL

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The observations around which the discussion in this article are centred were made under rather unfavorable experimental conditions and are offered not as conclusive evidence on disputed points but rather as suggesting problems and technique for future investigations.

The writer after several months of "stomach trouble" was put in March 1919 under the care of Dr. Einhorn of N. Y. City, whose very ingenious method of treatment gave her opportunity for the following study. The stomach was given a complete rest for two weeks during which time duodenal feedings were given. This was accomplished by direct feeding into the duodenum by means of a tube which passed from the mouth into the duodenum. This tube was **not withdrawn** during the two weeks period, but every day—from 6 a. m. to 8 p. m.—at two-hour intervals, from 240-300 c. c. of food (milk, raw egg, sugar of milk, and, toward the end of the treatment, butter) were forced through it into the duodenum. The apparatus which permitted this treatment is described by Dr. Einhorn as follows: "The duodenal pump consists of a small metal capsule (14 mm. long and 23 mm. in circum.) which is perforated and can be unscrewed. This communicates with a long, thin rubber tube (8 mm. in circum. and one metre long), and is marked at 40 (I. cardia), 56 (II. pylorus), 70 (III), and 80 cm. distance from the capsule. At its end is a tip, to which a syringe can be attached." (6:86)

The greatest part of this paper will be devoted to a discussion of hunger, but some observations on and interpretations of appetite, fulness and emptiness, thermal sensitivity, will be given.

*Hunger.*—The experimental findings of Cannon and Washburn, later verified and extended by Carlson, Boring, and others, have convinced most readers that hunger is a sensation or sensational complex concomitant with the periodic, intermittent contractions of the empty or nearly empty

stomach. Carlson holds that each separate contraction is synchronous with a hunger pang, and that the intensity and duration of the hunger correspond pretty closely with the strength and the duration of the stomach contractions. He also found that his subjects locate the sensation of hunger in the stomach. His data obtained from observations on fasting subjects is of special interest in connection with the observations reported in this paper.

In the case where Carlson and one of his assistants underwent a five day starvation period they found that there was an increase rather than a decrease of the gastric tonus and the hunger contractions during the period (4:128); that the sensation of hunger was almost continuous after the first day of starvation, i.e. it did not wholly disappear during the intervals between the vigorous gastric contractions; and that during the first three days the hunger was greater than during the last two although the contractions were greater in the last two days than on the first three. (4:135) They also found that appetite was increased during the first few days and then decreased so that toward the last there seemed to be indifference toward food "despite the persistent hunger call of the stomach." (4:136) The discrepancy in the parallelism between the intensity of the gastric hunger contractions and the intensity of the subjective hunger sensations was due, Carlson is inclined to believe, to the depression of the Central Nervous System. (4:136) In the case of the man who under Carlson's observation completely fasted for fifteen days and for the subsequent eight days except for the daily injection of a quantity of cotton fibre it was found that the hunger contractions were continuous with practically normal rhythm and intensity but that the subjective sensations appeared to be somewhat weakened, tinged with an element of general epigastric distress or sick stomach. The appetite sense or desire for food was modified or obscured by a tendency to a persistent bad taste in the mouth, yet the dominant element in consciousness was reported to be the thought of food and eating. (5) In the treatment given the present writer the stomach was kept empty—except for one half-wine-glass dose of liquid medicine (bismuth and magnesium) given three times a day—for a period of fourteen days. Despite this continued emptiness, hunger—except in the few cases noted below—was not felt. This result seems at variance with those of Carlson and considered in connection with the manner of her treatment gives rise to a number of questions: (1) Are stomach contractions inhibited by duode-

nal feedings; (2) If not, is it then true that stomach contractions are the most important concomitant physiological factor in hunger; (3) Is it possible, as has been suggested, that intestinal contractions play a large, if not the principal part, in hunger and that duodenal feedings inhibit these but do not inhibit the stomach contractions?

Carlson incidentally raises some of these questions and gives some experimental evidence that helps to answer them. He believes that intestinal contractions do take place during hunger, but that they play a very small part, if any, in the sensation of hunger. The proof of such a part is still wanting (4:83). In regard to question (1) above, Carlson describes some experiments made upon dogs which show that, in this case at least, stomach contractions are reflexly inhibited by stimulation of the intestinal mucosa. Intestinal and gastric fistulas were made upon twenty-four young female dogs and records of the effects of intestinal stimulation upon stomach contractions were made. It was found that gastric juice, chyme, acids, alkalies, water, milk, oil, introduced in 10 c. c. amounts into the small intestine inhibited gastric hunger contractions and gastric tonus for varying periods. "The longest inhibition obtained in any one experiment was produced by 10 c. c. of milk in the gut. In this case the inhibition lasted thirty minutes." (4:198)

The writer of this paper has no objective experimental evidence that might help in the answering of the questions given above but believes that such evidence is necessary in order to answer them and makes the following suggestions for further investigations. (1) That by the devising of some apparatus—possibly an adaptation of the apparatus used in her treatment—the presence of and the interval of periodicity of duodenal contractions be obtained;<sup>1</sup> (2) that stomach contractions be recorded during a period of duodenal feedings; (3) if it proves that periodic duodenal contractions are existent that the effect upon these be determined (a) during stomach feedings, (b) during duodenal feedings, (c) during a period of starvation.

It may well be that the duodenal feedings given the writer were frequent enough to cause a continuous inhibition of the stomach contractions and that for this reason during the greater period of the treatment she did not feel hunger. If this does explain her lack of hunger it would be interesting to determine experimentally how long the interval between

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<sup>1</sup> Carlson (4:82) mentions that in the duodenal fistula case of Busch contractions of the small intestines were noted in hunger.

duodenal feedings could be made and still have hunger absent. Whether or not the intestines play a rôle in the hunger sensation the writer cannot determine from any objective experimental evidence which she has, but that they do play such a rôle is suggested by certain introspections which she made during her period of treatment. As will be shown later in the paper, her introspective study of the sense of "fulness" convinced her that this was located in the small intestine and it was to this same location that she at times attributed "hunger." During the first week of treatment the duodenal feedings were begun at six o'clock in the morning. This generally necessitated waking her and as the feedings were begun immediately, time for introspection was lacking. On the last eight mornings of the treatment feedings were not begun until eight o'clock and on six, possibly seven,<sup>2</sup> of these mornings "hunger" was felt before the duodenal feeding was given.

Her introspections of this first morning, March 29, when she reported this early morning hunger contain the following statements: "Getting hungry: localized where the 'full' feeling is felt." On one other occasion, March 25, she wrote: "11:30. Feel a little 'hungry:' localized in the duodenum(?)." On March 28, 4 P. M. she wrote: "Before the feeding, felt fulness in the colon, also some sensation (pressure?, slight hunger?) localized in the lower stomach." On March 28, 4 P. M. she wrote: "Slight hunger: localization 'pit' of stomach." Later when she had more definitely localized the sensations in the intestine she felt that "lower stomach" and "pit" had really signified intestine. These introspections of the writer indicate that hunger may be felt at least partly in the small intestine. Perhaps it should be mentioned that at the time when the treatment was being given the previous experimental findings in regard to hunger, etc. were but vaguely known to the writer. The problem which she set herself at the time was to observe *when* she felt hunger, not *where* she felt it. For this reason she is inclined to regard her spontaneous though carefully made observations as of considerable value. During the period of the last three days hunger was reported as having been present at three times other than early in the morning but the exact time was not recorded. Her introspective notes show no localization of hunger except as quoted above. As stated before, localization was not her problem. Altogether then

<sup>2</sup> The writer did not positively identify the sensation of this morning as that of hunger.

during her two weeks of treatment hunger was felt but twelve times. It may well be that hunger was present at a few other times for strict attention to the problem was not always possible. Perhaps this is true of all hunger reports. At any rate the writer feels that her observations are on the whole truly representative.

Cannon, Washburn, Carlson, all make a good deal of the *time* relations between hunger and stomach contractions. They find that hunger is always reported *after* the beginning of stomach contractions. We have stated above that hunger was felt in the early morning before the duodenal feedings were begun and if it is true that duodenal feedings inhibit stomach contractions then this early morning hunger may have been due to the fact that the stomach contractions had not yet been inhibited because no feeding had been given during the night. But the fact that hunger was felt at other times during the day despite the fact that the time of duodenal feedings was kept constant is not so easily explained by this theory. To the writer's mind it raises the question whether or not after all the factor of "general weakness" is not a part of the hunger complex.

Hurst (7) quotes with approval Tiedemann's "admirable analysis of the sensation of hunger" in which hunger is said to be a sensation of emptiness of the stomach and the general sensation of malaise and weakness of the body as a whole. That hunger is more than local emptiness Hurst argues from the fact that in cases of prolonged starvation food relieves the emptiness but not the general feeling of malaise.

"a much larger quantity of food being required to satisfy hunger of the starved tissues than that of the empty stomach. For the former digestible and nutritious food is required, for the latter bulk is of primary importance. This is well seen in patients with a fistula of the upper part of the small intestine . . . I have myself observed one. The patient was constantly hungry, although he ate enormous quantities of food. His stomach always felt full, but the general sensation of hunger remained, as most of the food escaped from the fistula with the result that the tissues continued to be starved." (7:40-41.)

This general sensation of hunger Hurst thinks to be dependent upon the requirements of the tissues,

"it is increased when these are excessive owing to abnormally active metabolism, as in diabetes and some cases of Graves' disease." (7:40.)

The sensation of emptiness experienced during a period of starvation Hurst believes to be partly localized in the intestines. The cause of this sensation of emptiness is best explained by motor activity.

"The sensation of emptiness in the intestines, like the corresponding sensation in the stomach, can best be explained as a result of periodical motor activity in an organ which is abnormally excitable as a result of the absence of normal stimuli for an unusually long period." (7: 41.)

Carlson and Boring do not agree that weakness is a part of hunger. Both weakness and emptiness are accessories of hunger, according to Carlson. Emptiness he says is

"a peculiar feeling in the entire abdominal region. This feeling is continuous, not intermittent like the pangs of hunger. . . . It is probable that the increased tonus of the abdominal muscles in consequence of the empty state of the stomach and the intestines, contributes to the feeling in some way. . . . We question whether any part of the feeling of emptiness originates in the stomach itself. It is not so difficult to understand how a hypertonic and rhythmically contracting empty stomach may give rise to the sensations of tension, pressure, and gnawing pain. But how can it cause the sensation of emptiness, unless this feeling is merely negative of the sensation of fulness? On the other hand, if the tonus of the abdominal muscle does not suffice to maintain the normal intra-abdominal pressure when the stomach and the intestines are relatively empty and strongly contracted in hunger, the tension on all the visceral organs would not be diminished and this in turn would alter the pressure relative to the peritoneum and mesentery. If this is the factor in the origin of the feeling of abdominal 'emptiness' in hunger, the sensation should be diminished in man by lying down, in comparison with that felt when standing." (4: 93-94.)

The writer of this paper has certainly always considered the consciousness of emptiness as a part of her hunger complex. As to whether or not this "emptiness" decreases upon lying down she cannot say. But in her case at least it was experienced while lying down.

As to Carlson's positive analysis of hunger, he writes: "It is more or less an uncomfortable feeling of tension, or pressure and pain referred to the region of the stomach." (4:6) He quotes with approval the following analysis of hunger given by Boring.

"Upon a background of dull pressure, which is sometimes recognized definitely as kinaesthesia or the equivalent muscular pressure, there is set a dull ache or gnawing pain which characterizes the hunger. Both pain and pressure are referred to the region of the stomach. The pain is noted as fluctuating, as rhythmical, as unstable." (4:25-26.)

Kinaesthesia, pressure, pain, seem then to be the components of hunger for both Carlson and Boring. Perhaps what the writer of this paper called "hunger" in the cases noted was not what these two would call hunger. Certainly she included in it what she calls emptiness. Also at times there was in it or perhaps one should say *with* it a consciousness of weakness. In this connection the following note from her introspections

is interesting. "April, 1. Up a little while today. Find myself very weak. Weighed, and found had lost seven pounds up to date since beginning treatment. Felt some 'part' of what have called hunger in the past: but hunger of the kind when I have felt sick. Rather bad, weak feeling; while the hunger in the morning is more localized. Is a gnawing sensation. This is a good feeling: feel fine when have it." This introspection indicates to the writer that the consciousness of weakness can be separated in introspection from the other sensations. Perhaps "emptiness" too could be so separated. But that the sensations located in the stomach should be separated out from the complex and be called "hunger" while those in the intestines should be called "emptiness" seems hardly justifiable. Probably all form a part of hunger. To the writer's mind hunger is a perception. Moreover she finds that in her everyday life what functions as "hunger" contains the sense of "emptiness" more often than it does pain. May it not be that this is a question of individual differences? The writer is reminded of Boring's analysis of appetite in which he points out that the stomach mucosa sensations which Carlson gives as a necessary part of appetite seem to be an individual affair. He writes: "In interpreting this pattern as an essential component of appetite, Carlson and Braaffadt presumably put upon it their own individual meanings, which are, apparently, not completely in accord with those of other observers." (3:453) May not the same thing be true of hunger? Boring would probably dissent to this, insisting that the difference in the two cases is that in hunger we are dealing with a fusion of sensations while in appetite we have an attitude or meaning. If this is true then in the former case all normal persons would have the same components fused, while in the latter the sensory processes correlated with the attitude might vary in different individuals. The writer is raising the question whether it may not be true that hunger too is an "attitude" rather than a fusion? She certainly believes that the meaning of hunger is a constant part of hunger and she raises the question whether or not the sensory components (if one can make this distinction between meaning and sensory components) may not vary in individuals? Had she a record of her stomach contractions during her treatment she might conclude that only during stomach contractions did she feel hunger. But may it not also be true that without this sense of emptiness she would not experience hunger? Certainly she always did sense emptiness when she was hungry. And it is true that



she experiences what she calls hunger when pain is absent. Carlson and Boring report hunger without emptiness but always have pain in hunger. May it not be that in all of these cases hunger is present but with different sensory components? Or perhaps certain sensory components (perhaps kinaesthetic) are always present in hunger while other components vary in different individuals?

As to the consciousness of weakness the writer is inclined to agree with Carlson that this is not necessary in hunger. In her own experience, as her introspections show, hunger, at times, seemed to be accompanied by a consciousness of buoyancy and strength while at other times by that of weakness. This is also true of the hunger felt in the writer's every day life. On the other hand her introspections during treatment show that hunger was felt after exertion more than at other times.

Before leaving the discussion of hunger it is interesting to add part of a conversation with Dr. Einhorn, who feels that the need of food plays a part in the hunger process and points out the fact that in over 500 cases in which he has given the duodenal feeding treatment in very few instances is hunger reported to him. This is not true of rectal feedings where assimilation of food is much less than in the case of duodenal feeding. It may be, of course, that duodenal but not rectal feedings inhibit stomach contractions and hence the lack of hunger in the first case and the presence of it in the second case is accounted for. This is one of the points which future investigation will probably answer.

*Appetite.*—As to appetite during the treatment never did this force itself upon consciousness but came only when sight, smell, or the thought of food provoked some desire for it. This never happened however after a duodenal feeding, such a feeding seeming to "satisfy" the appetite. When appetite *was* felt there was decided "mouth-consciousness," i.e. kinaesthetic images of tongue movements, pressure images of "pucker," what seemed to be sensation from increased salivation. At times when the food was seen there was a motor tendency toward it. There seemed to be no gastric component present. Sometimes immediately before a duodenal feeding was given the writer watched food served and "desire" for food was often felt. In no case, however, did this *arouse* hunger. Introspections for 7-7.30, March 29 read: "Getting hungry: watched trays served, great desire for food tastes. 'Coffee-ah!' 'Brown rolls!' (these in vocomotor imagery)." With these images went the accompany kinaesthetic and pres-

sure images and sensations in the mouth. From her experience the writer believes that hunger and appetite are separated conscious states or attitudes. There may be mutual influence in a number of ways.

*Sensation of Fulness.*—One of the most outstanding features of the treatment was what the writer called the sensation of fulness. When the feedings were first given a rather widespread reaction occurred. Warmth (a sort of flushing) was felt over the whole body, most marked in the face and limbs. A thrilly, tingling feeling in arms and legs was rather dominant. This went up and down the limbs much as a shiver runs up one's back, but in this case it was a warm running thrill not a cold sensation, as in the case of shiver. A feeling of weakness was present and toward the end of the feeding a sensation of fulness. It is hard to describe this sensation for although it has some of the sensory components of what we sometimes term "bloating" or consciousness of gas in the intestines it had more localized muscular sensation than this. It seemed to be localized in one place, high up in the abdomen. Fulness seems the only word to express the sensation. It was somewhat like the sensation occasioned when upon washing out the stomach one feels that as much water as one "can hold" has been poured in and that it must be taken out. In both cases, i.e. in both the stomach and the intestine, fulness may pass over into nausea. In the case of the duodenal feedings there was a consciousness of pushing against the stomach, at least it seemed to be against the stomach for it was against that part where nausea was being felt. Nausea has always seemed to the writer to be localized in the stomach. At least it seemed higher up than the sensation of fulness, when they were present at the same time. Toward the end of the period of treatment the sensations of warmth, weakness, thrilling were not present in any marked degree. The sensation of fulness was present in all feedings and never was the writer able to take the feedings while sitting up. This seemed to increase the sensation of "fulness" and gave an added dragging-down sensation. It also occasioned the nausea more easily.

From experiments Hurst concludes (7:35) that the "sensation of fulness" is due to the stretching of the muscular coat and is probably shared by all hollow viscera. Carlson (4:112) points out that there must be a certain amount of tonus reaction of the stomach before tension or pressure on the walls of the stomach will produce the sensation of

fulness. The fact that the writer of this paper did not feel this sensation of fullness until the end of each feeding and that the sensation was felt more easily and markedly when the food was forced in more rapidly lends support to Hurst's contention, although one wonders if the food stays in one place long enough to give rise to muscular distention. At any rate the sensation of fullness *was* present under the conditions mentioned and apparently the small intestine is sensitive to distention. It may be mentioned that although qualitatively the sensation of fullness in the intestine resembled the sensation of "fulness" felt in the stomach after a very large meal, it was not felt in the same place.

One factor that made at least relative localization of sensations fairly easy and certain, was that the writer was experiencing fairly constant pain in the pyloric region of her stomach—due, probably, as tests revealed, to inflammation in this region. Both the sensation of fullness and hunger (at times) were localized lower than this pain. It should be stated that the writer's stomach is considerably dilated and that for this reason the localization of her sensations may be wrong. Even so the relative positions would be correct.

*Thermal Sensitivity.*—A few rough observations were made upon thermal sensitivity. Of course the tube used in the treatment was very small and single-walled thus allowing heat or cold to be quickly conducted to the surface. But as localization of alimentary sensations has been found to be pretty accurate this fact need not invalidate her observations. The writer believes that during her two weeks of treatment she became pretty competent and accurate in her ability to localize a sensation as one coming from the different parts of the alimentary canal. The strict localization of her pain and of her sense of fullness and hunger gave her what might be termed "land-marks." And then again introspection is not a new business to her.

The problem of the thermal sensitivity of the stomach seems to stand somewhat as follows. Hurst found that water from 40-50 degrees C. and also ice-water introduced into the stomach by means of an india rubber tube placed inside an ordinary stomach tube gave no thermal sensations (7:5). Boring, also using a double-walled tube, found that water at from 50-80 degrees C. produced a sensation of warmth and water at from 0-30 degrees C. a sensation of cold, both being referred to the stomach. (1:40) Carlson too concludes from experiments that "The stomach mucosa is endowed with heat and cold nerve-endings." (4:111)

From her own experience the writer believes the oesophagus, the stomach and the duodenum to be sensitive to thermal stimulation, the latter two being sensitive only when the stimulus is rather extreme, and the duodenum possibly not sensitive to warmth. In most cases the sensation of warmth occasioned by her feedings was confined to the upper part of the oesophagus. On March 28 attention was turned for the first time to this problem and introspections of that day read: "During several of today's feedings gave strict attention to temperature sensations: could sense none although when I forced the food down more rapidly it felt a little different." On March 29 introspections read: "No temperature sensations on forcing it faster." At other times when the food was given hotter than usual a vague, undefined sensation was felt in the stomach and duodenum. This was not recognized as warmth.

On the day that the tube was to be withdrawn Dr. Einhorn kindly consented to allow the writer to perform a few experiments upon thermal sensitivity. These consisted in having an experimenter<sup>3</sup> very forcibly inject a syringe full of water at varying temperatures through the tube into the duodenum. The writer opening wide her throat, held the tube away from the mouth and throat surfaces, closed her eyes so as not to know what stimulus was being given, and observed and reported the sensations experienced. One syringe full of water at each of the following temperatures was used with the following results. At 40° and at 44° Fa. unmistakable cold was sensed. This was very widespread in the abdomen and according to the writer's best introspective ability was localized both in the stomach and in the duodenum. At 54° the cold did not seem so widespread and it was doubtful whether or not it was at all localized in the duodenum. At 104°, 106°, 108°, 112° Fa. warmth was felt in the stomach but it was not as widespread as the cold and the writer felt rather doubtful about its being in the duodenum. At 115° it felt considerably "hotter," more widespread, and was possibly sensed in the duodenum, although the writer was not sure of this last point.

The writer offers these few observations on thermal sensitivity not as conclusive evidence in any sense but merely as having suggestive value. The experiments, together with her observations during the whole treatment, do incline her to the view that the stomach certainly and the duodenum prob-

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<sup>3</sup> The writer's brother, Dr. Malcolm S. Campbell, kindly performed these experiments.

ably have thermal sensitivity. Both seem more sensitive to cold: although higher degrees of warmth might have given different results. The whole problem should be put to further experimentation.

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